NASA Procedural Requirements

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Chapter 11 NASA Meteoroid Environment Program

11.1 Introduction

11.1.1 This chapter specifies the implementation and components of the NASA meteoroid environment (ME) program. NPD 8700.1, NASA Policy for Safety and Mission Success, addresses the inclusion of SMA as an integral part of every NASA program and project to protect the public, astronauts and pilots, NASA workforce, and high-value equipment and property . The ME Program is included within the scope of NPD 8700.1, NASA Policy for Safety and Mission Success. The risk assessment and shielding/mitigation approach must combine micrometeoroid (MM) and orbital debris (OD) to be accurate and effective. Requirements for limiting orbital debris generation are found in NPR 8715.6, NASA Procedural Requirements for Limiting Orbital Debris.

11.1.2 Meteoroids are defined as naturally occurring free flying space objects and are typically generated as a result of collisions between asteroidal objects or released from comets.

11.1.3 The objective of the NASA ME Program is to understand the flux of meteoroids which may impact spacecraft traveling in and beyond Earth's orbit. Meteoroids impacting spacecraft are a quantifiable risk due to the potential for puncturing pressurized volumes (e.g.; space station modules, propellant tanks) or destruction of components (e.g.; engines, electronics). Plasmas generated by very high speed meteoroids can also adversely affect spacecraft electronic systems. While meteoroids have never been definitively proven to have destroyed a spacecraft, there have been several in-flight anomalies attributed to meteoroid impacts, including the loss of the Olympus satellite to control system failure induced by a Perseid shower meteor impact. Understanding the meteoroid environment can help spacecraft designers to better protect critical components on spacecraft or avoid critical operations such as extravehicular activities during periods of higher flux such as meteor showers, especially those failures which could lead to loss of mission or loss of human life.

Note: See paragraph 11.2 for definitions associated with this chapter.

11.1.4 While this chapter does not place any specific requirements on spacecraft design and operations, it does require that spaceflight managers overtly consider the ME.

11.1.5 Meteoroids are described by their sizes, compositions, and velocity vectors. Those which pose a risk to spacecraft fall into three broad categories:

a. Particles with masses less than 10 -6 grams (i.e.; sandy dust particles). These particles are generally too small to damage spacecraft as they nominally vaporize upon impact.

b. Particles with sizes greater than 100 grams (i.e.; baseball size). The flux of these particles is relatively low and, as a result, has a very low probability of impact. However, objects of this size can produce numerous high speed particulates upon impact with the Moon, thereby posing a risk to lunar surface operations.

c. Particles with sizes/masses between paragraph 11.1.5.a and paragraph 11.1.5.b represent a risk to spacecraft and are the focus of the ME Program.

11.1.6 Appendix I of this NPR discusses the size range of meteoroids, their risk, and the systems which are used to monitor the meteoroid flux.

> *Note: This chapter does not discuss the methods and systems for observation and determination of the ME. If more information is needed, please contact the NASA Meteoroid Environment Office at Marshall Space Flight Center .*

11.2 Definitions associated with this chapter

a. Flux - The number of particles passing through a unit area in a given time. Flux is normally expressed in units of number per square meter per year. For risk calculations, meteoroids are simplified to be spherical with a density distribution. While this is a gross assumption, it provides an accurate representation of the meteoroid environment for use in engineering assessments.

b. Meteoroid Environment - The sporadic meteoroid environment consists of a diffuse background of meteoroids of cometary and asteroidal origin and represents a continuous risk to spacecraft throughout the year. This constant flux must be mitigated by an appropriate spacecraft design, which can lead to significant engineering challenges.

c. The Marshall Space Flight Center Meteoroid Engineering Model (MEM) defines the sporadic meteoroid environment for spacecraft in interplanetary space and Earth orbit. It is to be used as a tool by spacecraft designers.

11.3 Responsibility

11.3.1 The Chief, Safety and Mission Assurance, shall:

a. Lead the NASA ME Program (Requirement 57254).

b. Establish policies for the understanding of the ME (Requirement 57255).

c. Provide resources and support needed to continue ME research and quantification by the ME Program (Requiremen (Requirement 57256).

d. Ensure that software tools, models, and their associated databases are provided (or made available) to aid programs/projects in ME evaluation of mitigation options (Requirement 57257).

e. Provide oversight of the Meteoroid Environment Office (MEO) in the implementation of the NASA ME Program and coordination of ME research with spaceflight programs and organizations inside of and outside of NASA (Requirement 57258).

f. Ensure assistance and expertise in ME is provided to NASA programs/projects in the evaluation of the ME upon request by the programs (Requirement 57259).

11.3.2 The cognizant Mission Directorate Associate Administrator shall:

a. Ensure that evaluation of the ME is included in NASA spaceflight programs in design and operations (Requirement 57261).

b. Determine the level of acceptable risk due to ME (Requirement 57262).

> *Note: Level of acceptable risk is normally expressed jointly for ME and Orbital Debris. (See NPR 8715.6, NASA Procedural Requirements for Limiting Orbital Debris, paragraph 1.3.2.1.)*

> *Note: Upon request, the NASA MEO can provide technical expertise on ME.*

11.3.3 The Assistant Administrator, Office of External Relations, shall endeavor to incorporate the NASA ME Program interfaces i n negotiated international agreements for space activities and launch services (Requirement 57263).

11.3.4 The Director, NASA Marshall Space Flight Center , shall provide administrative support for the NASA MEO and may supplement MEO funding (Requirement 57264).

11.3.5 NASA Spaceflight Program/Project Managers shall evaluate ME risk mitigation measures for inclusion in spaceflight design and operations (Requirement 57265).

> *Note: Upon request, the NASA MEO can provide technical expertise on ME.*

Note: The risk assessment and shielding/mitigation approach must combine MM and OD to be accurate and effective. Design, test, and evaluation of MMOD shielding and inherently technical/engineering functions have been responsibilities that have been managed directly by each NASA Spaceflight Program/Project and tasked to the technical/engineering line organizations.

11.3.6 The NASA MEO shall:

a. Lead the technical work for the ME Program (Requirement 57267).

b. Provide technical expertise and assistance to NASA mission program/project managers in technical ME assessments by providing information and/or directing queries to the knowledgeable technical staff (Requirement 57268).

c. Provide technical support to NASA management in the understanding of the ME (Requirement 57269).

d. Perform and support research into improved techniques for determination of the ME in government and academia (Requirement 57270).

e. Develop techniques and technical support for NASA programs/projects and NASA partners in the inclusion of ME quantification with probabilistic risk assessments (i.e.; NPR 8705.5, Probabilistic Risk Assessment (PRA) Procedures for NASA Programs and Projects) and other risk quantification documents (i.e.; NPR 8000.4, Risk Management Procedural Requirements) (Requirement 57271).

f. Develop, validate, and update ME models and databases (such as the MEM) and make those software tools available to NASA programs and partners (Requirement 57272).

g. Coordinate the collection of ME data and information internal and external to NASA (Requirement 57273).

h. Collect information on spacecraft meteoroid impacts and resulting damage and maintain a database of close calls and mishaps due to meteoroids (Requirement 57274).

Note: Spacecraft programs/projects are responsible for determining ME damage and any associated mishap or close call reporting. The NASA MEO will collect that information for NASA-wide use.

i. Develop and provide forecasting of the ME for NASA spaceflight programs upon request (Requirement 57275).

j. Develop ME fluxes for Earth orbital and lunar regions (Requirement 57276).

k. Develop and maintain a NASA Guidebook on ME to provide further information and guidance to NASA programs/projects, ME professionals, and NASA partners (Requirement 57277).

Note: Development of the NASA Guidebook on ME will be a technical update to existing NASA ME documentation which includes NASA SP-8013, NASA Micrometeoroid Environment Model [Near Earth to Lunar Surface], NASA SP 8038, Micrometeoroid Environment Model [Interplanetary and Planetary], NASA TM 4527 Natural Orbital Environment Guidelines for Use in Aerospace Vehicle Development, and SSP 30425 Space Station Program Natural Environment Definition for Design. The NASA Guidebook on ME will not contain requirements for ME mitigation.

l. Provide ad hoc assistance to the Department of Defense and other U.S. Government departments and organizations on matters related to the characterization of the ME for NASA space missions (Requirement 57278).

m. Participate in the determination, adoption, and use of international meteoroid mitigation guidelines through international forums (Requirement 57279).

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